

Proposed Transformation of Integrated Resource Planning by Electric Utilities for Arizona Corporation Commission

White Paper by Henry M. Goldberg and John M. Cordes

Submitted to ACC Energy Modernization Rules Stakeholder Workshops Docket

May 16, 2019

IRP Process Transformation Drivers

- Dramatic Reductions in Costs of Renewable Energy and Storage
- Global Warming and Health-Related Impacts of Fossil Fuel Emissions
- Other States and Corporations Transitioning to 100% Clean Electric Power
- ACC Dissatisfaction with Utility IRPs: Excessive Reliance on Natural Gas
- Arizona has a great solar resource, and reasonable land and construction costs

Goal of White Paper:

Ensure the Integrated Resource Planning Process makes every attempt to provide the cleanest, healthiest, lowest-cost electric power for Arizona citizens/utility customers.

Path to Achieve:

A properly-structured transformed IRP Process that includes:

- a) ISE Oversight and a competitive and well-planned all-source RFP**
- b) Makes every effort in the RFP and planning process to have annual goals that maximize the use of clean, low-cost energy resources heading to 100% clean electric power by 2045-2050.**
- c) ISE communication with ACC to ensure RFP results and IRP planning scenarios are clearly understood and consistent with ACC objectives**

Xcel Energy: Highly Competitive Bidding for Renewable Energy

- 2017 “All-Source Solicitation” to Replace Coal Power Plants
- Received 350 bids:
 - 152 bids for standalone solar at median price of \$29.50 per Mwh
 - 96 bids for standalone wind at median price of \$18.10 per Mwh
 - 87 bids for solar-plus-storage at median price of \$36 per Mwh
 - 11 bids for wind-plus-storage at median price of \$21 per Mwh

(Lazard: natural gas plants \$42 - \$78 per Mwh; coal plants \$60 - \$143 per Mwh)

- Arizona tremendous potential for solar power development:
 - state with most sunlight per yr., low land and labor costs
- Arizona competitive bidding prices for clean energy should be open to all sources:
 - solar, wind, various storage technologies, biomass, next-gen nuclear, geothermal

Federal Government Policy Impact on ACC IRP Process

- Growing concern from public about climate change: 69% of Americans worried about it
- AZ must reduce its allocation of water from Lake Mead due to declining water in Colorado River
- Strong support in Democratic Party for substantial climate change action.
- A number of Republican politicians in favor of carbon taxes on fossil fuels
- Possible federal gov't actions that would impact ACC Integrated Resource Planning:
 - carbon taxes
 - mandates to eliminate coal-fired plants in near term and reduced nat. gas plants over time
 - mandates to introduce electric vehicles
 - requirements to replace fossil-fuel end user equipment with electric-powered equipment
 - upgrading national electric power transmission networks and regional trading of power
 - limiting fugitive methane emissions from natural gas production/transportation/distribution
 - regulations on energy efficiency of buildings and appliances

Scenarios Electric Utilities Should Examine in IRP Process

1. Carbon Tax proposals to capture the social cost of carbon (damage from climate change and health-related costs)
2. Impact of using only clean energy options in meeting future electric capacity growth
3. Impact of replacing all existing coal plants by 2030 and natural gas plants by 2045-2050
4. Impact of higher natural gas pricing due to carbon taxes, regulation of methane emissions, LNG exports
5. Realistic possibilities for emerging technologies:
 - new storage approaches, biomass/waste, next-gen nuclear power, geothermal, carbon capture (CCS & CCU)
6. Dramatic increase in electric power demand over time:
 - mandates to transition to electric vehicles
 - replacement of fossil fuel eqpt with electric-powered eqpt in residential/commercial/industrial sectors
 - exporting Arizona solar power to other states
7. Energy Efficiency Approaches Impacts on Demand:
 - smart grid to lower peak power demand from price signal information
 - federal subsidies and regulation of energy efficiency for buildings and appliances
8. Best model for using distributed solar/wind power to supplement central utility sources of power
9. Longer planning horizons than current 15 years to achieve 100% clean electric power by 2045 -2050

Optimized Wholesale Competition vs Retail Electricity Competition

ACC is considering moving to retail electricity competition to reduce prices for consumers. This white paper focuses on optimizing wholesale competition for electricity generation.

Advantages of Optimized Wholesale Competition

1. Most advantages of electricity competition come from using newer lower-cost sources of power generation from solar/wind plus storage or natural gas.
2. Large incumbent utilities can provide stable, large-scale, long-term contracts for power developers to bid on: results in large number of bidders with lowest possible costs.
3. Utilities optimize all sources of supply for cost-effectiveness & reliability across all users.
4. ACC can focus on incumbent utilities' RFP process optimization and running scenarios to most effectively meet future clean-energy objectives.
5. Retail competition involving many service providers much more difficult to administer IRPs whether they cost-effectively and reliably meet transition to 100% clean energy.
6. No issues with consumer fraud, forcing incumbents to divest all generation assets, or fairness to residential customers of commercial customers going off grid.

Recommendation for ACC “Independent System Evaluator”

ISE Objective Team of Experts: Ensure Integrated Resource Planning Most Effective for ACC, consumers, State of Arizona

- **As part of IRP and before IRP approval:** Ensure maximally-competitive “all source” RFP processes for clean-energy options
- Work with utilities to understand cost, reliability, flexibility features of clean-energy bids received **with an effort to maximize the clean, low-cost power sources.**
- Require utilities examine all relevant planning scenarios: **including 100% clean energy by 2050.**
- Communicate results of RFP bidding processes and IRPs to ACC commissioners/staff:
 - influence technologies considered; clearly understand information/analysis done
- Work with utilities and ACC on 5-year action plans:
 - comprehensive RFP bidding process
 - completion of IRP activities/reports
 - implementation activities (permitting sites, new transmission lines, building projects)
 - for 2025 implementation: process begins in 2020

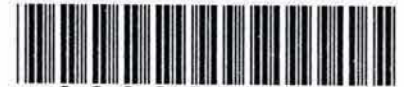
Conclusion

- ACC has been dissatisfied with excess reliance on natural gas, slow transition to renewables
- ACC does not currently have cost and other relevant information on clean-energy options to evaluate feasibility of cost-effective alternatives to natural gas
- ACC needs assistance in evaluating electric power consumption over time scenarios
- Federal government policy framework responding to environmental impacts from carbon emissions dramatically change the way IRP planning in Arizona must be done
- Arizona adopting “Clean Resource Energy Standard and Tariff” such as 100% clean electric power by 2045 – 2050 requires careful consideration of scenarios to transition away from conventional coal and natural gas power.

Goal of White Paper: Cleanest, Healthiest, Lowest –Cost Electric Power

Properly Structured IRP Process with ISE Oversight Can Achieve This

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Workshops Docket No. RU-00000A-18-0284

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Transformation Drivers

The Arizona Corporation Commission (ACC) requires Arizona's public electric utilities to engage in Integrated Resource Planning (IRP) to demonstrate how they will meet future electric power requirements of Arizona consumers in a cost-effective and reliable manner. Rules require that every two years utilities file a 15-year plan on how they will fulfill the power needs of customers identifying the sources of generating power and percentages used. The ACC approved using such an IRP process for electric utilities in 2010.

Dramatic Reductions in Costs of Renewable Energy and Storage

Since 2010 there have been dramatic changes in the options for clean-energy electric power generation. These include: major reductions in the costs of renewable energy from solar and wind sources, as well as new and declining-cost sources of power storage (multiple battery storage options, molten salt in concentrated solar plants, pumped hydro, and various other approaches) to supplement intermittent solar/wind power. These solar/wind options with storage (particularly low-cost battery storage) need to be evaluated thoroughly in upcoming IRPs to minimize energy costs for all Arizona customers.

There are also evolving technological options in other sources of carbon-free power such as biomass and waste, nuclear power, and geothermal power; sizeable potential for distributed power generation and microgrids; and the substantial cost savings from expanded energy conservation/efficiency and new approaches to demand-side management.

Global Warming and Health-Related Impacts of Fossil Fuel Emissions

There will be enormous environmental costs from continued burning of fossil fuels that have been extensively documented by climate scientists and health scientists. The UN Intergovernmental Panel on Climate Change and The Fourth National Climate Assessment recently released by the federal government both warn of massive economic costs to the country and world in the future if net greenhouse gas (carbon dioxide, methane, etc.) emissions are not reduced towards zero by mid-century to prevent global warming beyond 2°C (3.6°F) above pre-industrial levels. Future threats include major and possibly catastrophic sea-level rise from melting

ice sheets in Antarctica and Greenland and warming oceans flooding coastal areas worldwide, many severe hurricanes/wildfires/heat waves, droughts and crop failures, greater stress on aging infrastructure, and warming/acidifying oceans causing marine species extinction. Indeed, the planet could become unlivable for our children, grandchildren, and future generations if global warming is not halted.

Additionally, the health effects of air pollution from fossil fuel burning are also substantial – thousands of premature deaths and multi-billions of dollars in health care costs per year in the U.S. from respiratory problems and other illnesses. The combined costs and risks of global warming and air pollution from fossil fuel emissions are critical drivers for the adoption of cleaner energy sources for electric power in the future.

Other States and Corporations Transitioning to Clean Electric Power

Five states, California, Nevada, New Mexico, Washington, and Hawaii, have already committed to 100% carbon-free electricity by 2045 – 2050, and other states are moving in this direction as well. More than 100 U.S. cities have also committed to getting 100% of their electricity from renewable sources.

If Arizona successfully transitions to a full clean electric power infrastructure, it will attract corporations committed to using 100% clean energy (e.g. Google, Apple, Microsoft, Amazon, Facebook, Verizon, and eBay) to locate more of their data centers here, which are key to the state's future economic development.

Arizona Corporation Commission Dissatisfaction with Utility IRPs

In March 2018, the ACC rejected IRPs received from the state's investor-owned utilities Arizona Public Service (APS), Tucson Electric Power (TEP), and UniSource Energy Services (UNS). A key reason for the rejection of these IRPs was continued excessive reliance on natural gas for a substantial share of power generation. Presumably, the commissioners' primary concern for excessive natural gas use was that cleaner energy options may be less expensive for consumers over time. Commissioner Andy Tobin's Energy Modernization Plan (released in January 2018) called for 80% of Arizona's electricity generation to come from clean energy sources by 2050.

The electric utilities' IRPs are not heading towards achieving this goal. APS' 2017 IRP planned for 33% of its electric power to be supplied by natural gas plants in 2032 (up from 26% in 2017) and with coal-fired plants still supplying 11% of their power in 2032, yielding a total of 44% fossil-fuel power in 2032 (compared to 47% in 2017). The majority of APS' new generation needs in the IRP still come from natural gas plants, though in February 2019 it did announce a new initiative to add 200 MW of battery storage to its existing solar plants and an additional 500 MW of solar plus storage and standalone battery storage by 2025. Although TEP has been a leader in auction processes for solar/wind plus storage projects, its 2032 reference case portfolio mix still relies on 38% coal generation and 26% natural gas, supplying 64% of its power from fossil fuels (as compared to 80% in 2017).

The ACC is rightly questioning whether utilities are properly examining clean energy alternatives to fossil-fuel power in transitioning to their future generation mixes, and has placed a temporary moratorium on the building of new natural gas power plants. APS and TEP are putting more emphasis on solar plus storage projects, but there should be new processes put in place to ensure the maximum use of clean energy when economically effective and environmentally required.

Xcel Energy – Highly Competitive Bidding for Renewable Energy

Xcel Energy, Colorado's largest electric utility, is an important case study of an electric utility establishing a competitive bidding process to obtain remarkably low cost bids for solar/wind power standalone and with storage. In 2016, Xcel proposed to shut down two coal plants in the state and replace their output with roughly 700 MW of solar, 1 GW of wind, and 700 MW of natural gas by 2023. That would put Xcel's Colorado energy mix at about 55 percent renewables. In 2017, Xcel issued an "all-source solicitation" to meet this objective.

A huge number of developers responded with bids for renewable energy standalone or coupled with storage at unprecedentedly low prices. They received about 350 bids in total: 152 bids for standalone solar at a median bid price of \$29.50 per Mwh; 96 bids for standalone wind at a median bid price of \$18.10 per Mwh; 87 bids for solar-plus-storage with a median bid price of \$36 per Mwh; and 11 bids for wind-with-storage at a median bid price of \$21 per Mwh. There were also 28 bids for standalone battery storage projects ranging in size from 25MW

with 4-hour duration to 150MW with 10-hour duration. For comparison, Lazard's widely-publicized national analysis of levelized costs of energy in late 2017 found costs to build and operate combined cycle natural gas power plants between \$42 to \$78 per Mwh and coal-fired power plants between \$60 - \$143 per Mwh. In June 2018, Xcel selected projects that provide about 1100 MW of wind generation, 700 MW of solar generation, and 275 MW of large-scale battery storage, which have been approved by the Colorado Public Utilities Commission.

The Xcel solicitation of bids reveals that there is enormous potential to consider new solar/wind power with storage projects if an all-out bidding process is implemented by an Arizona utility. APS has commented in 2018 that relying more on renewables will increase electricity costs for Arizona consumers as it has in California. However, California started installing solar power plants ten years ago when prices were 12 - 14 cents per kwh, far higher than the bids Xcel received (median bid for solar of 2.9 cents per kwh). Developers are taking advantage of declining costs of renewables and storage as well as federal tax credits, but are also anxious to gain market share in the growing renewable energy sector. Arizona consumers could pay lower prices with renewable energy and storage than building new natural gas fired power plants to meet future demand.

Arizona has tremendous potential for solar power development being the country's state with the most sunlight per year, so the results for competitive solar power bidding could be staggering in the future. Arizona currently imports low-cost solar power from California as a result of the energy imbalance market, but cannot rely on this power being available to meet major future electric power capacity requirements. Moreover, Arizona has significantly lower land and labor costs than California, making it a more attractive location to build solar plants for exporting power to other states (including California).

Arizona competitive bidding processes for clean energy should be open to all sources: solar, wind, biomass (e.g. from thinning forests to prevent catastrophic wildfires) and waste, geothermal, next-generation nuclear, various storage technologies, and carbon capture & sequestration or utilization (CCS or CCU) technologies for natural gas power plants.

Given the potential lower costs, better air quality and health benefits for Arizona citizens, and important environmental benefits of clean energy, the ACC should require that utilities modify their IRPs to consider maximizing the use of clean- energy options for base load and peak power needs.

Federal Government Policy Impact on ACC IRP Process

There is growing concern from the general public about climate change – according to recent surveys 69% of Americans are worried about it and are aware of impacts occurring now such as severe hurricanes, wildfires, and droughts. Arizona already must reduce its allocation of water from the Lake Mead reservoir because of declining water in the Colorado River as a result of global warming. Federal government politicians are considering ways to address the climate change crisis. There is strong support in the Democratic Party for substantial action, particularly if they gain control of Congress and the White House in the 2020 election. A number of Republican politicians are also in favor of options such as carbon taxes on fossil fuels.

Possible actions by the federal government that would impact ACC Integrated Resource Planning include: carbon taxes, mandates to eliminate coal-fired power plants in the near term and reduction in natural-gas fired power plants over time, mandates to introduce electric vehicles, requirements to replace fossil-fuel burning end-user equipment with electric-powered equipment in the residential/commercial/industrial sectors, supporting upgrades to the national electric power transmission networks and regional trading of electric power, legislation to limit fugitive methane emissions from natural gas production and transportation, and regulations on energy efficiency of buildings and appliances.

ACC Integrated Resource Planning must respond to such federal policies and implement them in the most effective way for the state of Arizona. Carbon taxes and fugitive methane emissions legislation would raise the price of natural gas and coal-fired power. Mandates to eliminate coal-fired power plants and reduce natural gas power plants over time would require replacing these sources with clean energy alternatives in the most cost-effective and reliable manner. Requirements to introduce electric vehicles and end-user electric equipment would dramatically increase the demand for electric power (from clean sources) over time. Conversely, efficiency standards on buildings and appliances would reduce demand. The ACC must ensure electric utilities are properly considering these potential policy changes and their impacts on supplying power and the resulting costs to consumers.

Scenarios that Electric Utilities Should Examine in IRP Process

Currently Arizona electric utilities' IRPs are not required to include various scenarios of importance to the public as the federal government considers implementing policies to reduce environmental costs of climate change from carbon (CO₂ and methane) emissions related to generating power with coal and natural gas-fired power plants as well as air pollution health impacts from fossil fuel burning. Going forward, it will be critical that utilities' IRPs address the following types of issues:

1. Carbon tax proposals are now being considered to capture the social cost of carbon (i.e. estimating the present-valued costs to the U.S. economy over time from climate change and health-related costs of air pollution). Some proposals start at \$40 ton per ton of CO₂ emissions and rise significantly over time, and the proceeds of the taxes may be refunded to consumers to be revenue-neutral or some of the tax revenues may be used for other clean energy programs. Utilities should examine the impact of proposed federal government carbon tax scenarios over time on coal and natural gas power plant usage (both existing and proposed new plants) as these plants become more costly relative to clean energy alternatives. How would the cost of electricity to consumers be impacted by this?
2. What would be the impact of using only clean energy source options in meeting the requirements for future electric power capacity growth? Could a maximally-competitive RFP process for solar/wind plus storage eliminate the need for new natural gas power plants?
3. What would be the impact of replacing all existing coal-fired power plants by 2030 and all existing natural gas fired power plants by 2045 or 2050 with clean energy alternatives in terms of cost of electricity to consumers and reliability of the system?
4. What is the impact of higher natural gas pricing scenarios (due to carbon taxes, regulation of methane emissions on natural gas production and

transportation, domestic supply tightening with LNG exports) be on the implementation of clean energy alternatives to replace natural gas power plants, and the resulting impact on electricity costs for consumers?

5. What are the realistic possibilities for emerging technologies such as new storage approaches, biomass and waste, next-generation nuclear power, geothermal power, and carbon capture from natural gas power plants to be implemented in Arizona? How effective would these approaches be in enhancing reliability with greater use of solar/wind power?
6. Examine scenarios of dramatic increases of electric power demand over time with federal government policies to mandate transitions from gasoline/diesel vehicles to electric vehicles and replacement of end-user fossil fuel equipment with electric-powered equipment in the residential, commercial, and industrial sectors. Also consider the possibility of exporting Arizona solar power to other states.
7. Consider smart grid demand response implementations in maximizing end-user efficiency and lowering peak power demand from price signal information. How effective could this be in moderating electric power generating requirements and optimizing solar/wind power use? What would be the impact of expanded federal subsidies and regulation of energy efficiency for buildings and appliances?
8. What is the best model for using distributed solar/wind power to supplement central utility sources of power? How much distributed power is expected to be deployed under the above scenarios?

9. Longer planning horizons than the current 15-year requirement for IRPs are needed to understand utility approaches to achieving 100% clean electric power by 2045 or 2050.

Retail Electricity Competition

ACC Chairman Bob Burns has recently expressed interest in considering a retail electricity competition model for Arizona similar to that implemented successfully in other states such as Texas. Retail electricity competition would enable users to select their electric power generation supplier based on competitive pricing rather than be required to buy power from their monopoly electric utility provider.

A well-constructed ACC IRP process could determine the feasibility and likely impacts of Arizona moving to a retail electricity competition model in the future. IRP planning would still be required with suppliers of electric power under retail electricity competition to plan electric power capacity for the future and determine whether they meet new federal/state policies and assess the impacts on consumers.

Recommendation for ACC “Independent System Evaluator”

We recommend the ACC establish an “Independent System Evaluator (ISE)” to assist the ACC in working with electric utilities to effectively implement the proposals discussed above.

The ISE would be an objective team of experts with competence to work with electric utilities and the ACC to ensure Integrated Resource Planning is done in the most effective way to meet the future needs of the ACC, electric power consumers, and the state of Arizona.

The ISE would work with electric utilities and the ACC to perform the following functions:

- Ensure maximally-competitive RFP bidding processes for clean energy options including all relevant technologies (similar to the Xcel Energy approach for solar/wind power and storage, but also including other relevant technologies such as biomass, geothermal, next-generation nuclear, pumped hydro, and carbon capture).

- Work with utilities to understand the cost, reliability, and flexibility features of viable clean-technology options derived from the RFP process. Ensure that utilities appropriately consider these options in their IRPs.
- Require that Utility IRPs examine all relevant planning scenarios as discussed above.
- Communicate structure and results of RFP bidding processes and IRPs to ACC commissioners and staff so they can influence the technologies and scenarios considered in the IRP process and clearly understand the information derived and analysis done.
- Work with utilities and ACC on 5-year action plans to accomplish the above steps and near-term implementation of new projects. This includes: a comprehensive RFP bidding process for clean-energy options; completion of IRP activities and reports; and implementation (permitting sites, new transmission lines required, and building projects). This would typically all occur within a 5-year timeframe (2025 for process beginning in 2020).

Conclusion

The ACC has recently been dissatisfied with the IRP process partly because of excessive utility reliance on natural gas power and slow transition towards more renewable energy. The ACC does not currently have the cost and other relevant information on various alternative clean-energy options to evaluate whether cost-effective alternatives to this natural gas reliance are feasible. It also needs outside expertise to evaluate whether the electric power consumption over time scenarios being considered by utilities are reasonable.

The federal government policy framework for responding to environmental impacts from carbon emissions may dramatically change in the future impacting the way the ACC does integrated resource planning with utilities. Moreover, we believe Arizona should have a “Clean Resource Energy Standard and Tariff” replacing the existing REST, as proposed by ACC Commissioner Andy Tobin, but the goal should be to have 100% of Arizona’s electric power needs supplied from clean energy sources by 2045 or at latest 2050. All electric power suppliers in Arizona, including utilities that are not regulated by the ACC, should be required to meet this objective. New scenarios must be examined in utility IRPs for cost-effective and reliable approaches to transition away from conventional coal and natural gas power plants to clean energy in this timeframe.

We believe the approach outlined here with an Independent System Evaluator established to implement this is the most effective way for the ACC to transform its IRP process. It will result in providing sufficient information to the ACC so that they can properly evaluate clean-technology options and decide on the most cost-effective and reliable clean-energy transition for consumers, which is also consistent with state/national/international goals for a sustainable development path for the economy.

The overall result should be lower electricity costs for consumers, cleaner air and better health for Arizona citizens, and Arizona contributing substantially to national/international efforts to halt global warming.

There will likely be objections from utilities to interference with their existing IRP processes. There will also be objections from the coal and natural gas industry to increased emphasis on clean energy alternatives. However, the need for the ACC to ensure utilities are doing their utmost to properly evaluate and include clean electric power sources in their IRPs, and the requirement to comply with potential national directions on reducing environmental costs, must outweigh such objections.

Our goal in this white paper is to make every effort possible to provide the cleanest, healthiest, and lowest cost electric power sources for Arizona customers. To do so, the utilities must present the costs, benefits, and risks for clean energy options to allow the ACC to make the best decisions for Arizona. Properly structuring the IRP process with oversight by an ISE will ensure the ACC sees the options, pricing, reliability, and other relevant information to make informed decisions.

We appreciate the opportunity to present this white paper on proposed transformation of the Integrated Resource Planning process by electric utilities for the Arizona Corporation Commission.

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Bios attached.

Henry M. Goldberg Bio (energy-focused)

Henry M. Goldberg is originally from Edmonton, Alberta, Canada, and lived half of his life in Canada and half in the United States. He obtained his Ph.D. in Operations Research from Cornell University (College of Engineering) in 1976, and did post-doctoral study in energy policy modeling at MIT and Stanford University. He currently lives in Phoenix, Arizona.

Goldberg was a professor (tenured) at the University of Alberta from 1976-82. He and a colleague built the BALANCE model of long-term Canadian energy supply and demand, and used this model to analyze key Canadian energy policy issues. They developed the dynamic equilibrium energy modeling methodology to integrate supply (based on a multi-period linear programming model) and demand (based on a multi-period econometric forecasting model) for energy at consistent prices over time. They used this model to quantify the economic benefits to Canada of moving to world pricing for oil and natural gas.

Goldberg was a visiting professor/visiting scholar at Stanford University from 1982-85, affiliated with the Department of Operations Research, Institute for Energy Studies, and the Hoover Institution. He extended the BALANCE model to include Canadian natural gas exports to major US regional markets, and used this model to examine the benefits to Canada from deregulating natural gas export pricing and allowing free trade with the United States. He worked with Stanford faculty to organize conferences of market analysts and senior policymakers in industry, government, and academia from Canada, the United States, and Mexico to discuss key issues on the North American natural gas trade. Goldberg wrote a paper commissioned by the Premier of Alberta on the optimal future use of Alberta's natural gas resources. He also was a consultant to the Economic Planning Agency of Japan on modeling of Japan's primary energy supply system.

Goldberg worked in the telecommunications industry for many years as a systems engineer, strategic planner, and market analyst for AT&T Bell Labs, Nortel Networks, Industry Canada, and Reed Elsevier. He is currently Vice Chair of the Arizona Telecommunications & Information Council.

Since 2009, Goldberg has been a participant in OurEnergyPolicy.org, a U.S. national online forum of energy experts that discuss important energy policy issues. He authored the article "Creating an American Infrastructure Strategy" doing a preliminary analysis of the net economic benefits to the U.S. of addressing the global warming problem with clean-energy infrastructure strategies. He wrote numerous posts on his ideas and suggestions for the best ways the U.S. should address the global warming problem and achieve sustainable economic development. In Dec. 2017, he led an OurEnergyPolicy.org discussion on "Strategic Planning to Avert a Global Warming Catastrophe".

JOHN M. CORDES Bio

EDUCATION

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|------|----------------------------------------------------------------------------------------------------------------------------------------|
| 1974 | A. S. Business Administration
Onondaga Community College
Syracuse, New York |
| 1978 | B.S. Civil Engineering (Structural)
Syracuse University, Syracuse, New York |
| 2003 | Graduate - Business and Leadership Essentials Program
University of Calgary, Haskayne School of Business
Calgary, Alberta Canada |

EXPERIENCE

John Cordes is an accomplished energy professional with over 40 years of project management, business development and acquisition experience in the energy business with a history of successfully leading and closing of large scale and profitable energy investments. John was a Director and VP Development for several power companies and his experience in the energy business includes a lead role in management of development teams, project and company financial evaluations, acquiring power and electric distribution companies, structuring of transactions, due diligence, contract negotiation, bidding for PPA's, interconnection, permitting, strategic planning, project reporting, board presentations, development and project management of project pipelines, and construction management.

John was responsible for origination, development, permitting and acquisition of international energy investments with a value over US \$10 Billion. Experience includes lead roles in green-field development and acquisition of power facilities such as hydroelectric, solar, coal, natural gas, and acquisition of several large electric distribution companies. The 127Mw (AC) photovoltaic Arlington Valley solar farm, near Arlington, Arizona included.

John's international experience includes the North America, South America and Europe. He was a Board Member and Management Committee Member for several companies/partnerships.

In early 2012, John began full time work as independent consultant, under the name of Corporate Growth Solutions. Recent work includes performing consulting services for solar/battery storage and hydroelectric power projects in North America, which includes Arizona and other US western states, Mexico and Canada.